Washington State Board of Education

Working to Raise Student Achievement Dramatically

Washington State Science Standards: An Independent Review

Preliminary Report

Submitted
January 7, 2008

PROJECT TEAM

David Heil
Rodger W. Bybee
Harold A. Pratt
Kasey McCracken

DAVID HEIL & ASSOCIATES, INC.
Innovations in Science Learning

TABLE OF CONTENTS

INTRODUCTION

Washington's State Bard of Education contracted with David Heil & Associates, Inc. (DHA), to conduct a comprehensive review of Washington's current K-10 science standards. This review will analyze the strengths and weaknesses of the current standards in view of their current use in practice and student performance statewide, as well as benchmark them to recognized exemplar states and nations selected for their strategic relevance to Washington state. DHA will recommend specific ways to strengthen Washington's K-10 science standards, including adding appropriate grade level expectations for grades 11 and 12, so that Washington students will be better prepared with the science knowledge and skills needed to successfully enter the world of work and postsecondary education with the applied skills, computational fluency, and conceptual knowledge they need.

This preliminary report sets the stage for the full review and subsequent recommendations for the next generation of science education standards for the state of Washington. Included in this report is an overview of the project, a discussion of the nature and purpose of science education standards, summaries of relevant state and national reports and documents that will inform the review process, a description of the selection process for the states and nations that will be used as benchmarks in the review, a description of the Washington Science Advisory Panel, an assessment of the strengths and weaknesses of the current science standards based on input from the Washington Science Advisory Panel, and a preview of the likely areas for recommended changes to the science standards.

OVERVIEW OF THE PROJECT

The review of the Washington science standards will analyze the strengths and weaknesses of the current standards in view of their current use in practice and student performance statewide. In addition the review will benchmark Washington's Science Standards to recognized exemplar states and nations selected for their strategic relevance to Washington state. David Heil & Associates, Inc. (DHA) will recommend specific ways to strengthen Washington's K-10 science standards, including adding appropriate grade level expectations for grades 11 and 12. The goal of this process is to improve the science education standards so Washington students will be better prepared with the science knowledge and skills needed to successfully enter the world of work and post-secondary training and thrive as future citizens of Washington state and the world. The project team will conduct the review through a series of six steps:

Step 1. Research and Review Relevant Documents, Establish Criteria for Benchmark Selection, Summarize Preliminary Findings.

Step 1 was completed during the timeframe leading up to this report. The project team reviewed existing reports, studies and reviews and identified three states and two nations to serve as benchmarks in the review. The team has identify experts affiliated or familiar with these states/nations to be included in the Expert Review Panel described in Step 3 below. The project team also met with the Washington Science Advisory Panel, an appointed body of diverse citizens and stakeholders from across Washington State, to assess the strengths and weaknesses of Washington's current science standards.

Step 2: Develop Methodology and Instruments to Support Expert Review.

Now that the reference points for the review of the standards have been established, the team is currently developing appropriate instruments to support the comprehensive standards review. These guides will provide quantitative measures of the WA state standards with regard to each of the identified criterion, and additional data collection procedures will be developed to ensure that important qualitative data are captured as well.

Step 3: Expert Review of Washington Science Standards.

The project team has identified and confirmed participation for the seven members of the expert review panel who will help to conduct the comprehensive review of the Washington science standards. The panel is comprised of experienced content and grade level experts in science education representing appropriate benchmark states, nations or organizations as well as individuals with broad experience evaluating and/or implementing standards based science programs in Washington state and across the nation. The reviewers will be sent advance materials summarizing earlier findings and reviewed reports and studies to prepare for their review. Then the full Expert Review Panel will meet for a two-day review session chaired by Rodger Bybee. During this session they will utilize the tools developed in Step 2 to quantitatively and qualitatively evaluate the Washington science standards.

Step 4: Analyze & Interpret Results of Expert Review and Prepare Recommendations.
Following the compilation of results from the expert review, the team will work to analyze all of the data compiled to-date and will prepare recommendations for strengthening the standards, K-12.

Step 5: Facilitate Public Input into the Science Standards Review.
Following the development of a preliminary set of recommendations, the team will solicit public input on the recommendations by posting the document to the SBE website with an online system to capture feedback, and also by hosting three focus groups in locations throughout the state of Washington. In addition, the project team will continue to meet with the Washington Science Advisory Panel every other month throughout the six month review period.

Step 6: Prepare and Present Findings and Recommendations.
The project team will prepare and submit three reports to the SBE: The first report, this Preliminary Report, summarizes relevant material from researched and reviewed reports and studies; provides initial findings on strengths and weaknesses of the current K-10 standards; and previews areas most likely to be addressed in later recommendations. An Interim Report will summarize the strengths and weaknesses of Washington's current K-10 science standards in more detail, incorporating the expert review conducted using the nine proposed criteria and comparing Washington to strategically selected benchmark states and nations. Preliminary recommendations for changes to the current standards and incorporation of grade level expectations for grades 11 and 12 will be included in this second report. The Final Report will summarize the full comprehensive review process and findings, synthesize and summarize public and stakeholder input, and articulate a final set of recommendations for changes to the current standards and expansion of the standards to include grades 11 and 12.

Throughout the review process the project team will share findings with the Washington Science Advisory Panel and seek that Panel's input into the review process and the development of recommendations. Most notably, input from the Advisory Panel will be sought with regard to: assessment of the strengths and weaknesses of the current Washington State Standards; priorities for how the Washington science standards should serve the state of Washington; reviewing recommendations for revisions to the standards, based on the project team and Expert Review Panel's findings; the development of the process for obtaining public input; and review of the Final Report based on findings from public comment on the Interim Report.

NATURE AND PURPOSE OF SCIENCE EDUCATION STANDARDS

This discussion serves as an introduction to standards and their potential for improving science education in Washington State. The presentation begins by addressing the power of standards and concludes by addressing some key considerations in the use of standards.

THE POWER OF STATE STANDARDS FOR SCIENCE EDUCATION

The power of state standards lies in their capacity to change fundamental components of the educational system.

The standards, as a set of state policies, provide a comprehensive approach to changing policies, programs, and practices. By their design, standards direct attention to these domains and inform decisions about various components of the educational system. To the degree various agencies, organizations, institutions, and districts embrace the standards, they have the potential to bring greater coherence and unity to diverse components such as state curriculum frameworks and assessments, teacher education and professional development, textbook adoptions and curriculum implementations, and allocation of resources that support science education.

State standards for science education provide a perspective on educational improvement that emphasizes what all students should know and be able to do.

Using standards shifts perspective on improving education from inputs to the system, changes that we assume will enhance achievement such as time in school, homework, and use of instructional technologies to "outputs" such as defining the goals for 13 years of school science education. The intention of state standards is to clearly define the goals and content of science education and then change the various means of achieving those ends. Of course, educational change never works out as planned. Standards provide a new perspective, a different way of thinking about reform and achieving higher levels of scientific achievement.

Taking a school district as an example, the district uses state standards as the basis for identifying goals for the science education program—what all students should know and be able to do. The district could then either select or design assessments aligned with those outcomes and do the same for curriculum materials and instructional strategies. Such an approach would result in greater coherence for the school science program and subsequently higher achievement for all students.

Implementing state standards facilitates greater coherence among educational components.

The assumption behind this position is that greater coherence among goals, curriculum, instruction, assessments, teacher education, and professional development will enhance students' achievement. By some reports, for example, the Trends International Mathematics and Science Study (TIMSS), the U.S. has an incoherent educational system. Goals are only tangential to instructional materials which are not true to assessments, which are not aligned with professional development, and the list goes on. Using a basic definition, coherence occurs when a small number of basic components are defined in a system, and other components are based on or derived from those basic components. There is an orderly and logical relationship of educational components that affords greater comprehension of the whole system. How will state standards bring about greater coherence within science education? Over time, standards for science education will develop coherence by:

- defining the understanding and abilities of science that all students, without regard to background, future aspirations, or prior interest in science should develop;
- presenting criteria for judging science education content and programs at different grade levels including learning goals, design features, instructional approaches, and assessment characteristics;
- providing criteria for judging instructional materials, curricula, and learning experiences developed by national projects, state agencies, local districts, schools, or teachers; and
- including standards for the preparation and continuing professional development of teachers.

The content of standards emphasizes fundamental science concepts and basic processes of scientific inquiry.

Although it may seem that standards are at the center of science education, ultimately it is curriculum and teaching that matter most. In the end, students learn the content they are taught. This view directs attention to the content of the curriculum. Indeed, the standards help define that content. This said, school districts make decisions about the textbooks and materials used in the science program and teachers decide the particular emphasis and activities that students will experience. It is worth noting that the national standards and assessment frameworks recommend the development of fundamental scientific concepts and intellectual abilities as opposed to the current emphasis on facts, information, and topics.

One insight from high achieving countries (e.g., on TIMSS) is the need to reduce the number of science topics students encounter in a school year and to focus efforts on fundamental concepts and abilities. The standards should do this. However, there is an assumption that those with responsibility for curricular reform would reduce topics and reform programs so the topics in school programs present opportunities to learn fundamental science concepts. Instead, schools have viewed standards as topics that must be added to current programs. Such should not be the intention of the standards-based reform of the science curriculum.

The standards should present a view of scientific inquiry. Based on the historical importance of scientific inquiry, or the processes of science, the standards can extend current views from process skills such as observing, inferring, hypothesizing, and the like, to a development of cognitive abilities such as reasoning, critical thinking, and using evidence and logic to form explanations. In addition, the standards should recommend that students develop some understanding of scientific inquiry. Science as inquiry thus becomes a part of science content not just teaching strategies.

Finally, the standards can recommend a context within which fundamental concepts can be presented. For example, technology, personal and social perspectives, and history and nature of science can all provide appropriate contexts for use in curriculum reform.

> ***The standards provide the basis for a curriculum that is educationally coherent, developmentally appropriate, and scientifically accurate.***

If a school district uses standards as the basis for deciding the content of a school program, then it is important to make further decisions about how the content should be organized. Many school science programs lack coherence. That is, topics do not represent an organized and coordinated K-12 structure for content. The parts of science programs should make a whole science curriculum. Rather, most programs present a grade-level, course orientation, especially at the secondary level. Curricular coherence requires a strong vertical perspective that is then complemented by the traditional course or horizontal view.

Developmentally appropriate refers to a curricular perspective that includes the number, duration, repetition, sequencing, specificity, and difficulty of science concepts in the curriculum. Decisions relative to these issues should be based on students' developmental and learning capacities and the fundamental concepts and intellectual abilities as presented in the standards.

Science concepts must be accurate, given the age and developmental level of students. In general, the standards should recognize this criterium in the grade-level orientations for content. Another essential feature of "scientifically accurate" is expressed by the requirement of major concepts at the heart of science, but may cause some groups concern. Biological evolution is an example of this point. Omitting concepts, as opposed to topics, that are central to science disciplines results in curriculum that is not scientifically accurate. Holding the line on socially controversial concepts is a part of our educational responsibility to science. In a very real sense, representatives of states, school districts, and science teachers are responsible for the integrity of science as presented in school science programs.

State standards should facilitate alignment of state, district, and classroom assessment practices with curriculum goals and instructional approaches.

Teachers often lament, “I have to teach to the test.” Why, one might ask, is this a problem. The complaint betrays the observation that the tests do not contain the content valued by teachers and parents. A second complementary point can be identified within this problem. There exists a basic lack of coherence between what is taught and what is tested. It seems a simple educational task—align assessments with the curriculum goals and instructional approaches. State standards should contribute to this alignment.

What would “tests worth teaching to” be like? In simplest form, they would be consistent with the content of the curriculum. They would emerge from what teachers, school districts, and states propose they value. The content would be clearly defined and accessible. This then is a goal of state standards for science education.

ADDITIONAL CONSIDERATIONS

Release of new or revised state standards for science education will inevitably broaden and deepen discussion about science education in general and of those standards in particular. Although the community will have been aware of their development and opportunities for review and input, the actual standards will stimulate new discussions as different factions of the education community and the general public are confronted with the possibility of change. These discussions may be far ranging and, at times, appear counter-productive. Unfortunately, that is part of the process. Figure 1 outlines additional considerations and possible problems associated with the development and implementation of standards. Each issue is presented with a few relevant examples.

Figure 1. Additional Considerations in Developing and Implementing Standards

Assuming Content Standards are Curriculum
Example: The following list does *not* necessarily describe a sequence for instruction: Properties and changes in properties in matter. Motions and Forces. Transfer of Energy. *(from NSES, Physical Sciences, Grades 5-8)*
Using Content Standards to Describe Educational Experiences
Example: The following describes an educational experience rather than scientific content: Students will investigate life cycles of organisms.

Confusing Content Standards and Performance Standards

Example: The following illustrates the difference between content and performance standards:

Properties of Objects and Materials

Content Standard

"Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers."

(from NSES, Physical Sciences, Grades K-4)

Performance Standard

"Students will use rulers, balances, and thermometers to describe properties of objects and materials."

Stating Content Standards as Behavioral Objectives

Example: The following ilustrates a statement of a standard as a behavioral object:

At the completion of grade four, all students will be able to identify three kinds of rocks.

(NSES example)

As a result of activities in grades K-4, all students should develop an understanding of:

The Characteristics of Organisms.

Life Cycles of Organisms.

Organisms and Environments.

Confusing Content Standards and Curricular Topics

Example: The following illustrates curricular topics:

Light, Heat, Electricity, Magnetism.

Marine Biology.

Environmental Problems: Population and Resources.

Rocks and Minerals.

In conclusion, state standards for science education should provide a clear basis for improving policies, programs, and practices at the district, school, and classroom levels. This discussion serves as an initial orientation for DHA's work and future recommendations.

REPORTS FOR REFERENCE

An important first step in the process of reviewing the Washington Science Standards is to review the established national and international reports that inform current thinking on the format, content, and appropriate use of science standards. This section provides a description of two landmark publications of science standards: *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and the *National Science Education Standards* (National Research Council, 1996). It also describes the most recent frameworks available for three assessment systems that are currently used to measure student achievement in science: National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Programme for International Student Assessment (PISA). Finally, descriptions of the two Washington state science documents that will serve as the basis of the review are provided: *K-10 Grade Level Expectations: A New Level of Specificity* (2005) and *Preliminary Science College Readiness Definitions* (2007).

NATIONAL SCIENCE EDUCATION STANDARDS AND BENCHMARKS FOR SCIENCE LITERACY

National Science Education Standards

The *National Science Education Standards* (*NSES)* were developed by the National Resource Council under the guidance and review of the National Academies of Science and published in 1996. As stated in the NSES:

> The National Science Education Standards present a vision of a scientifically literate populace. They outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels… The standards apply to all students regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. They describe the science content that students should learn.

The content of NSES is unique among standards in that it contains more than content standards. The content standards are arranged by grade level spans (K-4, 5-8, 9-12). With the exception of Unifying Concepts and Processes, all eight content standards are included at each grade level span. The document contains the following standards:

- Standards for science teaching
- Standards for professional development
- Standards for assessment in science education
- Standards for science content
    - o Unifying Concepts and Processes K-12

  - Science as Inquiry
  - Physical Science
  - Life Science
  - Earth and Space Science
  - Science and Technology
  - Science in Personal and Social Perspectives
  - History and Nature of Science
- Standards for science education programs
- Standards for science education systems

Each of the nine science content standards is organized into three to five "categories" or broad conceptual topics. As an example the Physical Science Standards for grade span 5-8 contain three categories, "properties and changes in properties of matter, motions and forces, and transfer of energy." The standards are followed by a few pages of narrative that discuss the progression of learning through the grade levels and what is known about research on how students learn the content. A variety of classroom vignettes illustrating what the learning of the standards looks like in schools are inserted at various places in the document.

Within these standards a number of "evidences of understanding" are listed. These evidences of understanding are what are often considered the standards by the casual reader. These statements of understanding or abilities represent fairly large "grain size" amount of content and are often three or four sentences long at the upper grade spans making it possible to indicate the substance of what is to be learned and how extensive or elaborate the learning is to be. The stem of each standard reads; "As a result of their activities in grades (K-4, 5-8, or 9-12), all students should develop an understanding of …" The evidences of understanding are written as statements of major scientific ideas or concepts. The abilities of inquiry standards and the abilities of technological design standards are preceded with the stem "As a result of their activities in grades (K-4, 5-8, or 9-12), all students should develop abilities necessary to do…"

The standards were drafted by a working group of 18 volunteers made up of approximately equal numbers of classroom teachers, scientists, and university and K-12 science educators. The drafts were reviewed and edited by a small staff before being reviewed by the National Committee on Science Education Standards and Assessment, a large oversight group consisting of members of the National Academy of Sciences, and experts from a number of educational disciplines. After a thorough review of initial drafts the final document was reviewed using the National Research Council's rigorous Report Review Process.

Insights from the NSES include the manner in which inquiry and technology are handled and the use of the verb "understand." Both the abilities of inquiry and the understanding of inquiry are included in the content standards. In a similar fashion, the Science and Technology Standards include both the abilities of technological design and the understanding of science and technology. The use of the verb "understand" in the NSES and "know" in the Benchmarks for Science Literacy, discussed below, are considered to have the same level of depth and rigor.

Benchmarks for Science Literacy

The *Benchmarks for Science Literacy* (BMfSL) were developed by Project 2061 at the American Association for the Advancement of Science and published in 1993. The content in the Benchmarks was derived from an early report, *Science for All Americans (SFAA)*. The Introduction to the *Benchmarks* states that:

> SFAA answers the question of what constitutes adult science literacy, recommending what all students should know and be able to do in science, mathematics, and technology by the time they graduate from high school. *Benchmarks* specifies how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels. Together the two publications can help guide the reform in science, mathematics, and technology education.

Benchmarks is divided into 12 chapters. Each chapter contains the benchmarks for all four grade level spans (K-2, 3-5, 6-8, 9-12):

- The Nature of Science
- The Nature of Mathematics
- The Nature of Technology
- The Physical Setting
- The Living Environment
- The Human Organism
- Human Society
- The Designed World
- The Mathematical World
- Historical Perspectives
- Common Themes
- Habits of Mind

Each chapter opens with a short quote from SFAA and a few overall comments about the ideas to be learned and, in very general terms the kinds of student experiences that would foster learning. The chapters are divided into a small number (usually 4 to 6) of sections containing the benchmarks by grade level span. Each section has an introduction with comments on common difficulties in learning the ideas, on pacing over grade levels, and on clarification of the ideas in the benchmarks. Each grade span also has a few comments to clarify what "knowing" entails and suggestions of what students' experiences might include and what difficulties students might have. These comments are followed by the grade span benchmarks.

According to *Benchmark*s (page XII):

> In 1989, six school districts teams were formed in different parts of the nation to rethink the K-12 curriculum and outline alternative ways of achieving the literacy goals of *SFAA*. Each team, backed by consultants from and Project 2061 staff, was made up of 25 teachers and administrators and cut across grade levels and subjects. Working together over four summers and three academic years, the teams developed a common set of benchmarks. Drafts of

> *Benchmarks* were critiqued in detail by hundreds of elementary-, middle-, and high-school teachers, as well as by administrators, scientists, mathematicians, engineers, historians, and experts on learning curriculum design.

Important insights from this document include the manner in which learning is specified for each grade span. The "grain size" of *Benchmarks* is comparable to that in *NSES* each one containing enough information to indicate the substance of what is to be learned and how extensive or elaborate the learning is to be. The authors note that "Benchmark statements, whenever possible, are cast in language that approximates the intended level of sophistication." According to the authors of *Benchmarks,* "know" implies that students can explain ideas in their own words, relate ideas to other benchmarks, and apply the ideas in novel contexts.

ASSESSMENT FRAMEWORKS

Unlike the Benchmarks and the NSES, which provide standards that can be used to support the development of curricula and assessment tools, the following documents provide guidance on the science content to be assessed, the types of assessment questions, and the administration of the assessment for three systems for assessing student achievement in science: NAEP, PISA, and TIMSS.

National Assessment of Educational Progress (NAEP) Science—2009-2019

The National Assessment of Educational Progress measures student science achievement nationally, state-by-state, and most recently across selected urban school districts. Periodically, the framework underlying the science assessment is revised or updated. The *Science Framework for the 2009 NAEP* (hereafter referred to as *Framework*) contains recommendations for the NAEP Science Assessment to be administered in 2009 and beyond. The *Framework* provides guidance on the science content to be assessed, the types of assessment questions, and the administration of the assessment.

Any NAEP framework must be guided by NAEP purposes as well as the policies and procedures of the National Assessment Governing Board (NAGB), which oversees NAEP. For the NAEP Science Assessment, the main purpose of the *Framework* is to establish what students should know and be able to do in science for the 2009 and future assessments. Meeting this purpose requires a framework built on what communities involved in science and science education consider as a rigorous body of science knowledge and skills that are most important for NAEP to assess.

In prioritizing the content, the *Framework* developers used two national documents, *National Science Education Standards* (NRC, 1996) and *Benchmarks for Scientific Literacy* (AAAS, 1993), as representative of the leading science communities and their expectations for what students should know and be able to do in science. As curriculum frameworks, however, these documents cover a very wide range of science content and performance. The inclusive nature of both these documents demonstrates the difficulty of identifying a key body of knowledge for students to learn in science and, therefore, what should be assessed. Neither document limits or prioritizes content as is necessary for developing an assessment, posing a considerable challenge to the *Framework* developers and those using the *Standards* and *Benchmarks* for curriculum reform. The development of the *Framework* also was informed by research in science and science education, best practices, international assessment frameworks, and state standards.

Development of the NAEP 2009 was directed by a number of criteria. We include summaries of several criteria as they should inform decisions about the development of Washington science education standards and subsequent use of those standards for curriculum, instruction, assessment, and teacher education and professional development.

- **The NAEP 2009 Framework is informed by the National Standards and Benchmarks.** The *Framework* reflects the nation's best thinking about the importance and age-appropriateness of science principles and thus is informed by two national documents that were subject to extensive internal and external reviews during their development.
- **The NAEP 2009 Framework reflects the nature and practice of science.** The *National Standards* and *Benchmarks* include standards addressing science as inquiry, nature of science, history of science, and the human-made world. The *Framework* emphasizes the importance of these aspects of science education and should include the expectation that students will understand the nature and practice of science.
- **The NAEP 2009 Framework uses assessment content, formats, and accommodations consistent with the objectives being assessed.** The best available research guides assessment item design and delivery. The *Framework* is inclusive of student diversity as reflected in gender, geographic location, language proficiency, race/ethnicity, socio-economic status, and disability.
- **The NAEP 2009 Framework uses a variety of assessment formats.** These include well-constructed selected response and open-ended responses as well as performance tasks. In addition, multiple methods of assessment delivery should be considered, including the appropriate uses of computer technology.
- **Each achievement level—Basic, Proficient, and Advanced—includes a range of items assessing various levels of cognitive knowledge that is broad enough to ensure each knowledge level is measured with the same degree of accuracy.** Descriptions of Basic, Proficient, and Advanced are clear.

The design of the NAEP 2009 Science Assessment is guided by the *Framework's* descriptions of the science content and practices to be assessed. Figure 2 illustrates how content and practices are combined ("crossed") to generate performance expectations. The columns contain the science content (defined by content statements in three broad areas), and the rows contain the four science practices.

A double dashed line distinguishes Identifying Science Principles and Using Science Principles from Using Scientific Inquiry and Using Technological Design. The former two practices can be generally considered as "knowing science," and the latter two practices can be considered as the application of that knowledge to "doing science" and "using science to solve real-world problems."

Figure 2. Crossing Content and Practices to Generate Performance Expectations

		SCIENCE CONTENT		
		Physical Science content statements	**Life Science** content statements	**Earth and Space Science** content statements
SCIENCE PRACTICES	**Identifying Science Principles**	*Performance Expectations*	*Performance Expectations*	*Performance Expectations*
	Using Science Principles	*Performance Expectations*	*Performance Expectations*	*Performance Expectations*
	Using Scientific Inquiry	*Performance Expectations*	*Performance Expectations*	*Performance Expectations*
	Using Technological Design	*Performance Expectations*	*Performance Expectations*	*Performance Expectations*

The content statements are organized according to the three broad content areas that generally comprise the K-12 school science curriculum:

- Physical Science
- Life Science
- Earth and Space Science

The content statements are derived from *National Standards* and *Benchmarks*, as well as informed by international frameworks and state standards. The selection of science content statements to be assessed at each grade level focuses on principles central to each discipline, tracks related ideas across grade levels, and limits the breadth of science knowledge to be assessed.

The following science practices were found in the major sources used to develop the *Framework*. The practices to be assessed at grades 4, 8, and 12 are organized into four categories:

- Identifying Science Principles
- Using Science Principles

- Using Scientific Inquiry
- Using Technological Design

Selection and vetting of content was based on the thorough review of both the *National Standards* and *Benchmarks*. In addition, the document was reviewed by the committees responsible for development of the framework.

Insights gained from this review include:

- Basing science content and processes on the *National Standards, Benchmarks, TIMSS,* and *PISA;*
- Incorporating technological design;
- Structuring the document based on learning progressions; and
- Using clear and unambiguous statements of content (i.e., they are not behavioral statements).

The Program for International Student Assessment (PISA) Science 2006

PISA measures 15-year-olds' capabilities in reading literacy, mathematics literacy, and science literacy every three years. PISA was first implemented in 2000, and the most recent results are for the 2003 assessment.

Each three-year cycle assesses one subject in depth. The other two subjects also are assessed, but not in the same breadth and depth as the primary domain. In 2003, mathematics was the primary subject assessed, and in 2006 science was the primary domain. Results from PISA Science 2006 were released in December 2007. PISA also measures cross-curricular competencies. In 2003, for example, PISA assessed problem solving. Finally, each assessment includes questionnaires for students, school personnel, and parents.

PISA is sponsored by the Paris-based Organisation for Economic Cooperation and Development (OECD), an intergovernmental organization of 30+ industrialized nations. In 2003, 41 countries participated in PISA, including 30 OECD countries and 11 non-OECD countries. Data from 39 countries—29 OECD countries and 10 non-OECD countries—were used for the final analysis.

PISA uses the term *literacy* within each subject area to indicate a focus on the application of knowledge and abilities. Literacy refers to a continuum of knowledge and abilities; it is not a typological classification of a condition that one individual has or does not have. For the 2003 assessment, *scientific literacy* was defined as having the "capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (OECD 2003, p. 286). (Note: This definition was further clarified and elaborated for PISA Science 2006 [OECD 2006].) "Domains or curricular areas that might be applicable are not isolated within the single domain of mathematics, science, or reading" (OECD 2003, p. 156).

Compared to the curricular orientation of TIMSS (discussed in the next section), PISA provides a unique and complementary perspective by focusing on the application of knowledge in reading, mathematics, and science for problems and issues in real-life contexts. PISA's goal is to answer the question: Considering schooling and other factors, what knowledge and skills do students have at age 15? The achievement scores from PISA represent a "yield" of learning at age 15, rather than a measure of the attained curriculum at grades 4 or 8, as is the case with TIMSS. The framework for assessment is based on content, processes, and life situations. For example, in 2003 the content for mathematical literacy consisted of major mathematical ideas such as space and shape, change and relationships, quantity, and uncertainty. The processes describe what strategies students use to solve problems, and the situations consist of personal contexts in which students might encounter mathematical problems.

In PISA, a situation may be presented and several questions asked about it. Although some items are answered by selected response, the majority of items require a constructed response. The typical PISA item makes more complex cognitive demands on the student than the typical item from TIMSS or the National Assessment of Educational Progress (NAEP) (Neidorf et al., 2004).

Trends in International Mathematics and Science Study (TIMSS) Science 2003

TIMSS 2003 is the third comparison of mathematics and science achievement completed since 1995. TIMSS combines science and mathematics in one assessment and assesses student learning at different grades; in 2003, TIMSS evaluated grades 4 and 8.

Since 1995, TIMSS has been coordinated by the International Association for the Evaluation of Educational Achievement (IEA), an international organization of national research institutions and governmental research agencies. TIMSS is funded by the U.S. Department of Education, the National Science Foundation, the World Bank, the United Nations Development Project, and participating countries. IEA is located in Boston, Massachusetts. In 2003, a total of 49 countries participated in TIMSS at the fourth-grade level, the eighth-grade level, or both levels.

While PISA uses a contextual applications orientation, TIMSS provides a complementary perspective by linking assessments to the curricula of cooperating countries. Thus, TIMSS provides an indication of the degree to which students have learned concepts in the mathematics and science they have had the opportunity to learn in school programs. TIMSS answers the question: Based on school curricula, what knowledge and skills have students attained by grade 4? By grade 8? The achievement scores from TIMSS represent the "learned" curriculum at different grade levels, specifically grades 4 and 8. The following figure summarizes essential information about PISA and TIMSS.

Table 1. Comparing the 2003 PISA and 2003 TIMSS.

	PISA: Programme for International Student Assessment	TIMSS: Trends in International Mathematics and Science Study
Organization sponsor	Organisation for Economic Co-operation and Development (OECD)	International Association for the Evaluation of Educational Achievement (IEA)
Location	Paris, France	Boston, Massachusettes, USA
Countries	41 participating countries in 2003	25 countries participated in grade 4 46 countries participated in grade 8
Content	Reading, mathematics, science	Mathematics and science
Emphasis	Knowledge and abilities as applied to real-world issues	Knowledge and abilities as attained based on countries' curriculum
Age or grade	15-year-olds (mostly grade 10)	Grade 4 (9-year-olds) and grade 8 (13-year-olds)
Assessment cycle	Every three years, with one content area emphasized in each assessment. 2003 emphasis: mathematics; 2006 emphasis: science	Every four years with variation of grades

Perhaps the most educationally significant insight to be gained from the two international assessments emerges from the difference between TIMSS and PISA. TIMSS is grounded in the curriculum and provides feedback for how students are attaining what is intended and enacted vis-à-vis a country's curriculum. While not ignoring school curriculum, PISA asks how students can apply their knowledge in real-world situations. Lower U.S. scores on PISA suggest that students do not do as well as the majority of economic competitors when they have to demonstrate basic skills in contextual situations.

The evidence from international assessments indicates that U.S. students achieve reasonably well on curriculum-based assessments. But U.S. students do not do very well on context-based assessments, especially on content and basic skills associated with economic productivity. PISA provides a beneficial perspective, one that complements that of NAEP and TIMSS.

WASHINGTON STATE SCIENCE STANDARDS DOCUMENTS

Although this review will reference a number of documents related to the Washington state science standards, the team will utilize the documents *Science K-10 Grade Level Expectations: A New Level of Specificity* (2005) and *Preliminary Science College Readiness Definitions* (2007) as the basis of their review. Descriptions of each of these documents are provided below:

Science K-10 Grade Level Expectations: A New Level of Specificity

The Washington Science Standards, also referred to as the *Essential Academic Learning Requirements* (*EALRs*), were developed in 1997 and a set of Grade Level Expectations (GLEs) added in 2005. The Science EALRs were developed as a result of Washington's Basic Education Act of 1993 which spelled out the goal: "Provide students with the opportunity to become responsible citizens, to contribute to their own economic well-being and to that of their families and communities, and to enjoy productive and satisfying lives."

The K-10 EALR statements are based on the three overriding themes of Inquiry, Systems, and Application. Under each of these three statements are a small number of K-10 components. The GLEs and their respective Evidences of Learning are placed under the components by grade level spans (K-2, 3-5, 6-8, 9-10). The three EALRs are:

EALR 1: SYSTEMS	EALR 2: INQUIRY	EALR 3: APPLICATION
The student knows and applies concepts and principles to understand properties, structures, and changes in physical, earth/space, and living systems.	The student knows and applies the skills, processes, and nature of scientific inquiry.	The student knows and applies science concepts and skills.

The GLEs are written as short sentences beginning with a verb intended to identify Bloom's level of cognitive demand using the general progression of "know," "understand," and "analyze." A few of the K-3 GLE's are written with active verbs such as "observe" indicating the form of instruction involved. Many of the GLE's refer to a concept or idea but do not specify or elaborate on what is to be learned. The following is an example of a GLE of this nature. "Describe how a population of organisms responds to a change in its environment." (1.3.10)

The 2005 document, *K-10 Grade Level Expectations: A New Level of Specificity* indicates that "GLEs were developed from the 1997 EALRs through a process involving science educators, school administrators, university scientists, and representatives of prominent businesses from across Washington State. The Science Curriculum Instructional Framework (SCIF) team used material from the *Benchmarks for Science Literacy*, *Atlas of Science Literacy,* and the *National Science Education Standards* to clarify and give specificity to the EALRs by adding Grade Level Expectations and Evidences of Learning."

Preliminary Science College Readiness Definitions

College Readiness is a key educational strategy included in Section 8, Helping Students Make the Transition to College, of the state's *2004 Strategic Master Plan for Higher Education*. In 2006 under the auspices of the Higher Education Coordinating Board (HCEB) the science content development team began work on the Science College Readiness Definitions. A small team of six to seven high school and university personnel developed the definitions and attributes that were then reviewed by a group of 80 teachers and faculty.

The College Readiness Definitions and Attributes are designed to define what is needed for students to be able to successfully complete entry-level college coursework, without remediation, in two- and four-year colleges and universities. The college attributes reflect *how to learn*, while the college readiness definitions reflect *what to learn*. Student attributes include: demonstrate intellectual engagement; take responsibility for own learning; persevere through the learning process; pay attention to detail; demonstrate ethical behavior; communicate effectively; effectively read, parse and organize information presented questions/problems in order to formulate solutions.

The college readiness definitions include the follow six content areas and foundational skills: Big Ideas in Science (Physical Science, Life Science, and Earth and Space Science), Scientific Inquiry and the Nature of Science, Science and Society, Quantitative Analysis, Technology, and Communication.

The big ideas of science list the broad areas of science and do not define any specific ideas or concepts. The readiness document comments on this in the following way:

> The field of science is so broad that it does not allow for an exhaustive list of all that can or should be covered or considered important in the various science disciplines. Thus, Definition A emphasizes a student's proficiency with core science concepts—"big ideas" in science—at cognitive levels beyond those described in Washington State's grade 10 science EALR 1. Emphasis on learning moves from primarily knowing and understanding towards synthesizing and evaluating big ideas into a coherent and useful picture of the natural world, including physical, life and earth/space sciences.

The document consists largely of attributes and broad academic skills and does not attempt to assume the qualities of a standards document leading to an assessment. As the document states:

> Finally, in proposing English and science college readiness, the development teams emphasized that the intent is not to add another assessment layer or requirement to the K-12 system. While development of measures to determine whether individual students are "college ready" is viewed as valuable for both teacher and learner, additional statewide testing is considered unnecessary and, perhaps, counterproductive at this time.

SELECTED STATES AND NATIONS FOR BENCHMARKING

The project team used independent comparison studies and published reviews of state and international standards to inform the selection of states and nations to serve as appropriate benchmarks for the review of the Washington science standards. This includes comparison studies of state standards reviews (such as reports prepared by Education Week, the Thomas B. Fordham Institute and the American Federation of Teachers) and findings from national and international assessments (such as NAEP, TIMSS and PISA). In addition to these reports, states' performance on the 2002 State New Economy Index was used to provide additional context for selecting appropriate benchmarks. Washington Learns, described in more detail below, identified states that performed well on this index as important benchmarks for the state of Washington in the new economy.

Based on the team's review of these documents, the following states and nations were selected as benchmarks for the review of the Washington Science Standards:

- California
- Colorado
- Massachusetts
- Finland
- Singapore

Below are summaries of the documents that were reviewed to inform the selection of these states and nations, followed by a presentation of key results from these documents for the top-ten performing states on the 2002 New Economy Index and comparison results for nations that were considered as potential benchmarks.

Washington Learns (2006)

Washington Learns was created by the 2005 Washington legislature and tasked with conducting a review of the state's entire education system. The Washington Learns committees reviewed the Washington education system with the goal of determining how to provide high-quality lifelong learning in the 21st century. The reviewers proposed using the Global Challenge States as benchmarks against which to measure themselves. The Global Challenge States are the top eight performers on the 2002 New Economy Index (Progressive Policy Institute, 2002).

The New Economy Index ranks states on 21 indicators of their potential to compete in the new economy, grouped into the following 5 categories: knowledge jobs, globalization, economic dynamism and competition, transformation to a digital economy, and technological innovation capacity. Washington ranked second on the 2002 new Economy Index, and the states that were selected as benchmarks ranked first (MA), third (CA), and fourth (CO).

Quality Counts 2007 and Quality Counts 2006

Education Week provides an annual publication tracking state policies for improving K-12 education. Each publication includes a State of the States report which tracks education information and grades states on their policy efforts in areas such as K-12 standards, assessments and accountability systems. Much of the data included in the State of the States report is gathered through an annual policy survey, results of which are verified with documentation from the state.

The Quality Counts report provides overall grades for state performance in the area of standards and accountability that is based on the following indicators: 1) the adoption of standards in four core subject areas (english, mathematics, science, and social studies/history) and ratings of the standard's clarity and specificity; 2) the usage of five types of assessment instruments; and 3) the implementation of an accountability system that includes report cards, ratings (based on adequate yearly progress or state criteria), assistance, sanctions, and rewards. In the 2006 report Washington received a B for standards and accountability; Massachusetts received an A; California received a B+; and Colorado received a B.

The State of State Science Standards (2005)

The 2005 report is the latest in a series of three reports by that Thomas B. Fordham Institute that review state science standards (previous reports were in 1998 and 2000). The findings from this 2005 review are also reported in the *2006 The State of State Standards* (Thomas B. Fordham Institute, 2006).

The members of the Fordham evaluation team rated the science standards for each state on a 4-point scale based on 21 criteria in the areas of: Expectations, Purpose, and Audience; Organization; Science Content and Approach; Quality; and Seriousness. In addition to the 21 criteria within these categories, two additional criteria were given special attention by the reviewers: Inquiry and Evolution. The reviewers indicate that they include inquiry as an additional criterion because "these subjects are now treated in most standards documents as independent content or even as skills the students are expected to acquire." However, the reviewers caution against the overemphasis of inquiry in science standards, and state that in order to earn the highest rating "a state that gives the now-customary prominence to Inquiry had also to offer substantive, correct, and grade-appropriate material – subject matter – on the processes of scientific inquiry or on history or philosophy of science rather than empty encouragement toward good behavior." With regard to the treatment of evolution, the document states that in order to receive the highest rating the standards must introduce the main lines of evidence, including the fossil record, genetics, molecular biology, and development and connect these lines of evidence with Earth history.

Washington received a C for science standards based on the 2005 review. Massachusetts and California received A's, and Colorado received a B.

Smart Testing, Let's Get it Right (2007)

The American Federation of Teachers (AFT) conducted a review of state standards and reported on the strength of the content standards and the state's alignment of the science standards to the state's assessment system. To meet the AFT criteria for having state tests aligned to the standards, the state must: 1) have strong content standards; 2) provide evidence of alignment of the tests to the standards (e.g. item specifications, test blueprints, etc.); and 3) post the alignment evidence on the Web in a transparent manner. The majority of states met the AFT criteria for strong content standards in science. However, only 23 fully met the criteria for alignment between the science tests and the science standards. Washington, Massachusetts, and California met the AFT criteria for alignment at the elementary, middle school and high school levels. Colorado only met the criteria at the high school level.

Table 2 provides a summary of results of these reviews for the top-ten performing states on the 2002 New Economy Index, which were considered as potential benchmark states. In addition to findings from the New Economy Index, the Quality Counts 2006 and 2007 reports, the State of the State Science Standards 2005 report, and the AFT 2007 review, the table displays NAEP grade 4 and grade 8 results for 2005 and indicates the change in these results from 2000 to 2005. These results are included because they were another important indicator used in the selection of the benchmark states.

Following Table 2, Table 3 displays comparison results for nations that were considered as potential benchmarks. In addition to results from TIMSS and PISA, this table includes comparison information on the percentage of the population enrolled in secondary education and expenditures on education. The assessment results and additional contextual information, such as Finland's innovative means of implementing science standards, informed the selection of Singapore and Finland as benchmark nations.

Table 2: State Comparisons for Top-10 Ranking States on the New Economy Index

State/Nation	2002 New Economy Economy Rank	Most Recent Year Updated[1]	College Readiness Defined[1]	Regular Timeline for Revising[1]	Quality Counts 2006 Overall grade	Fordham Science	Levels Mtg AFT Criteria for Science Alignment[2]	2005 NAEP Grade 4 (Average Score)[3]	Direction of Change from 2000 to 2005[3]	2005 NAEP Grade 8 (Average Score)[3]	Direction of Change from 2000 to 2005[3]
Massachusetts	1	2006-07	NO	NO	A	A	e, ms, hs	160		161	+
Washington	2	2005-06	NO	YES	B	C	e, ms, hs	153	N/A	154	N/A
California	3	1998-99	YES	NO	B+	A	e, ms, hs	137	+	136	+
Colorado	4	2005-06	NO	YES	B	B	hs	155	N/A	155	N/A
Maryland	5	2000-01	NO	YES	A-	B	e, ms, hs	149	+	145	
New Jersey	6	2002-03	YES	NO	B+	B	e, ms, hs	154	N/A	153	N/A
Connecticut	7	2004-05	NO	NO	B-	C	NONE	155		152	
Virginia	8	2002-03	NO	YES	B	A	e, ms, hs	161	+	155	+
Delaware	9	1994-95	NO	NO	B+	C	NONE	152	N/A	152	N/A
New York	10	1995-96	YES	YES	A	A	e, ms, hs	N/A	N/A	N/A	N/A

[1] Source: Quality Counts 2007.
[2] Source: American Federation of Teachers. elementary = e; middle school = ms; high school = hs
[3] Source: The Nation's Report Card, Science 2005. Direction of change is shown only for those states for which the change was statistically significant. N/A indicates that NAEP results for at least one time-point are unavailable

Table 3: National Comparisons for Nations Considered as Potential Benchmarks

State/Nation	TIMSS 2003 Grade 4 Avg. Science Scale Score	TIMSS 2003 Grade 8 Avg Science Scale Score	PISA 15 yr olds Average Science Scale Score	Education Expectancy 2004*	Percent of Population in Enrolled Secondary Education*	Expenditures on Education as a percent of GDP*
Singapore	565	578	no data	N/A	N/A	N/A
Chinese Taipei	551	571	no data	N/A	N/A	N/A
Hong Kong	542	556	539	N/A	N/A	N/A
Japan	543	552	548	N/A	n/a	n/a
Australia	521	527	525	20.7	85%	3.7%
United States	536	527	491	16.9	82%	5.7%
New Zealand	520	520	521	19.1	95%	6.8%
Finland	n/a	n/a	548	20	94%	6.5%
Intl Ave	489	473		17.4 (OECD)		5.5% (OECD)

*Source: Quality Counts 2007.

WASHINGTON STATE ADVISORY PANEL

The Washington Science Advisory Panel, chaired by Jeff Vincent who is an SBE board member and chair of the Science Committee, will provide input into the review process and the development of recommendations. Most notably, input from the Panel will be sought with regard to: assessment of the strengths and weaknesses of the current Washington State Standards; priorities for how the Washington science standards should serve the state of Washington; reviewing recommendations for revisions to the standards, based on the project team and Expert Review Panel's findings; the development of the process for obtaining public input; and review of the Final Report based on findings from public comment on the Interim Report.

The Washington SBE appointed the Science Advisory Panel after publicly soliciting applications. The SBE received 68 applications and selected 19 diverse panelists to ensure representation of key stakeholders such as educators, parents, and practicing scientists. The SBE also worked to provide broad geographic representation within the state of Washington. Brief biographies for the 19 members of the Washington Science Advisory Panel are provided below.

Jeff Vincent, Chair, a member of the Washington State Board of Education, is the Chief Executive Officer and President of the Laird Norton Company LLC. He leads the Laird Norton investment team in the oversight of current investments, the development of new investment opportunities, and in the day-to-day management of Company activities. Jeff joined the Laird Norton Company LLC in January of 2001. Jeff has more than 20 years of business experience in such roles as CEO, CFO, corporate development officer, and strategy consultant. During 15 years of this experience, he worked with privately held family companies where he developed a fundamental understanding of how to successfully manage these types of entities. Jeff received his BSBA from Drake University, summa cum laude, and received his MBA from the Harvard Business School where he was a Baker Scholar.

Len Adams is a Health Promotion Specialist for the Tacoma/Pierce County Health Department, where he has worked for two years. Len worked for 27 years at the Pacific Science Center, where he held a variety of positions related to informal science education.

Jeffrey Bierman has been a physics professor at Gonzaga University for 12 years, and is a scientist with undergraduate degrees in mathematics and physics and a Ph.D. in experimental nuclear physics. He is also the parent of three children in Washington public schools.

Georgia Boatman teaches at Amistad Elementary School in Kennewick and is a National Board Certified elementary teacher with 31 years of teaching experience in grades 1-6 and Special Education.

Theresa Britschgi is in her third year as BioQuest Director at the Seattle Biomedical Research Institute. Theresa Britschgi earned her MS in Microbiology at Oregon State University prior to her work experience as a twelve-year veteran of the biotechnology/pharmaceutical industry.

Chris Carlson is a genetic epidemiologist at the Fred Hutchinson Cancer Research Center, and holds a Ph.D. from Stanford University in Genetics. He is also a parent of three children, legislative chair in his local PTA, and school board member.

Grant Fjermedal is the father of three children attending Seattle's North Beach Elementary School, where he serves as a member of the PTA Board and teaches science as a parent volunteer. A former science and medical writer for the Associated Press, Fjermedal is the author of four nonfiction books.

Jen Fox currently serves as a high school science coach in the Seattle School District. She taught biology, marine biology and botany at Roosevelt High School in Seattle for six years, and has worked on science teams at the state level.

Mario Godoy-Gonzalez has been teaching Physical Science and Biology/Biotechnology to English Language Learners (ELL) at Royal High School in Royal City since 1994. He began his teaching career in Chile in 1984.

Judy Kjellman has taught biology at Yakima Valley Community College for 39 years. She worked with a team of K-12 and college instructors to draft the preliminary Science College Readiness Definitions.

Sheldon Levias is a Learning Sciences Ph.D. student in the University of Washington's College of Education. He taught math and science for three years at Meany Middle School in Seattle and served for three years as a middle school science resource teacher in the Seattle School District.

Michael McCaw is a Senior Scientific Specialist in the Cellulose Fibers Technology group of Weyerhaeuser where he works on developing new uses and markets for cellulose fibers. He has worked in applied science for the company for over 20 years.

Brian MacNevin is currently a Teacher on Special Assignment with the North Cascades and Olympic Science Partnership, where he supports reform efforts of teacher leaders. He teaches at Shuksan Middle School in Bellingham and has 13 years of experience in science reform.

Judy Morrison is an Assistant Professor of Science Education at Washington State University TriCities, working with both preservice and in-service teachers. She has also taught chemistry, biology and physical science at both the middle and high school levels.

George (Pinky) Nelson is the Director of the Science, Mathematics and Technology Education program at Western Washington University. He holds a Ph.D. in astronomy, and has served on or directed many state and national science initiatives, including the AAAS Project 2061.

Kimberly Olson taught 6th/7th grade science for four years at Giaudrone Middle School in Tacoma and is now currently an Instructional Facilitator at Baker Middle School in Tacoma. She has been teaching for five years.

Steve Olson has been teaching physical science, chemistry, physics and mathematics for six years at Lakeside High School in the Nine Mile Falls School District. He also serves as chair of the science department.

Ethan Smith has taught at Tahoma High School in Covington for ten years and is currently serving as the Instructional Technology Coach for the Tahoma School District.

Barbara Taylor has taught in the Othello School District for 14 years: three years teaching 9th grade science and 10th grade biology, and 11 years teaching 8th grade science, math, and other subjects.

Kristen White has been teaching at Shahala Middle School in the Evergreen School District, Vancouver since 2001, and has over 15 years of teaching experience. She also served in the district office for two years as a Staff Development Specialist focusing on math, science and technology.

STRENGTHS AND WEAKNESSES OF CURRENT WASHINGTON SCIENCE STANDARDS

During the December 18th Washington Science Advisory Panel Meeting David Heil facilitated a discussion exploring the strengths and weaknesses of the current WA science standards as they are documented in the K-10 Grade Level Expectations (2005) publication. After brainstorming a list of 25 strengths the panel members independently ranked the top ten most significant strengths of the current standards. This process was repeated for weaknesses with a list of 31 recorded and rank ordered. Tables 4 and 5 list the strengths and weaknesses with the top ten in each list highlighted.

This facilitated discussion resulted in bried descriptions of strengths and weaknesses of the current standards that address a number of different aspects of the standards (e.g. approach, consequences of implementation, etc.). Although the weaknesses of the standards primarily focus on issues related to their design, many of the strengths describe the overall approach to the standards or the consequences of implementing the standards. For example, panelists endorsed the idea of standards for all students. They also pointed to several areas in which implementation of the standards has benefited education in the state of Washington, such as encouraging a more in-depth look at curricula and teaching, catalyzing district-wide professional development activities and starting cross grade-level discussions among educators.

With regard to the design of the current science standards, panelists' discussion of the strengths and weaknesses of the standards focused on the following key areas:

- **Connection to assessment.** Panelists ranked "no strong connection between standards and assessment" as the most significant weakness of the standards. This is interesting in light of the inclusion of the Evidence of Learning statements in the document, which are intended to serve as the basis for the development of WASL items. Additional comments by panel members suggest that this finding is driven by some panelists' experience of inconsistencies, between the standards and the WASL (e.g. differences in vocabulary usage).

- **Appropriateness of content.** While some panelists liked the progression of statements from Bloom's Taxonomy through the grade levels, others felt that too many of the standards are focused at the lower level of the taxonomy. Some panelists also felt that the standards should reflect personal "student attributes," which are statements of how students should learn similar to those used in the Higher Education Coordinating Board's Preliminary Science College Readiness Definitions document. Panelists indicated that the standards fall short on math and analytical linkages and that similar concepts in the math and science standards are described differently. Finally, panelists value that the standards are research-based and that they reflect the NSES.

- **Amount and relative weight of content.** Panelists had a positive response to the limited number of EALRs and GLEs but suggest that there is still too much information to be covered during the school-year. They were bothered by the implication that all content must be covered at each grade level, and, in particular, found that the standards for grades 9 and 10 were especially difficult to cover within a single grade-level year.

  In spite of panelists interest in reducing the overall load, panelists did support the inclusion of EALRs #2 (Inquiry) and #3 (Application) in the standards and indicated that they like the relative mass of EALRs #1 vs.#2 and #3 combined. However, panelists reported that in practice, educators may not cover EALRs #2 and #3 due to the amount of material required by EALR #1.

- **Format and Structure of the Document.** Panelists provided a number of both positive and negative comments about the format of the standards document. They appreciated that the document helps users to describe the progression of the requirements over time, that it does not specify curricula or instructional strategies (thereby allowing teachers to make these decisions), and that the appendices, such as the glossary of terms, are helpful.

  Panelists also found that the document is unclear on which component of each description constitutes the actual standard, and they felt that the document suffers from 1) a lack of informative narrative, which is included in national standards documents; 2) a confusing presentation that lacks a topography to facilitate discrimination between elements that are crucial versus those that are supporting; and 3) the omission of information to indicate where readers can locate additional resources.

Table 4: List of Strengths with Overall Rank Shown in Parentheses

STRENGTHS
(1) Recognizes "all students."
(2) Initiated more in-depth look at curriculum and teaching.
(3) Helps user to understand progression over time.
(4) Relative "mass" of number 1 vs numbers 2 and 3 is appropriate.
(4) K-10 focus results in science actually being taught in lower grades.
(4) Initiated cross-grade level discussion.
(5) There are only 3 EARLs and 42 GLEs (limited number is appropriate).
(6) Standards act as catalyst for district-wide professional development, curriculum development.
(7) EALR #2 (process of science) is included and given importance.
(8) Standards have given rise to clarity on core concepts.
(8) Lack of curricula/instructional specification is good.
(9) There is an even distribution of physical, earth, and life sciences in EALR #1.
(10) The level of content and grade-level distribution is based on NSES/research.
(10) Document provides examples for practitioners.
(11) Document is ambitious.
(11) Approach enables teachers to focus on their curricular/instructional decisions.
(12) Chose appropriate focus - looking at content from two different angles.
(13) Document is broadly distributed in the field.
(14) EALR #3 is also important, good to have it included.
(15) Evidence of student learning are grade-level targeted.
(16) Gives form to the "informal" sector.
(16) Used Blooms Taxonomy to outline lower levels in lower grades and higher levels in upper grades.
(17) Appendices are valuable (e.g. the glossary).
(18) Document is stronger for curriculum guidance.
(18) Document is stronger as test specification document

Table 5: List of Weaknesses with Overall Rank Shown in Parentheses

WEAKNESSES
(1) Lack of strong connection between standards and assessment.
(1) There is an implication that all content is covered in each grade.
(2) Grades 9-10 are extra challenging with too much too cover.
(3) Document lacks clarity on what component is the actual standard.
(3) Document suffers from being just a "block of lists," lacking narrative explanations.
(4) Not very usable document for teachers.
(5) Use of Bloom's Taxonomy - the verbs used are at the lower level of the taxonomy.
(5) GLEs don't describe detail necessary for implementation (curricula, instruction).
(6) Forces "too much" covered and not enough time to do it all.
(7) Vocabulary is not consistent with common practice in field.
(8) GLEs don't reflect personal "student attributes," as referenced in the Preliminary Science College Readiness Definitions.
(9) No clear aim is stated in the document.
(9) Details are often misinterpreted as implemented.
(10) Document says it will be the basis for WASL but doesn't hold true.
(11) Volume forces teachers to let go of later EALRs.
(11) Confusing presentation.
(12) Lack of "topography" to know crucial vs. supporting elements.
(13) Standards can feel intimidating and over encumbered, not enabling.
(13) Lack of support for the "big picture" view by teachers.
(14) There is a sense that there must be a "hidden curriculum" to bridge from standards to assessment.
(15) Falls short on math/analytical linkages.
(16) Use of systems term is confusing.
(16) Requires user to "look elsewhere" but doesn't provide resources.
(17) Similar concepts in math and science standards are described differently.
(18) Appears to be a "cell-filling" exercise (detailing expectations for every grade level).
(18) Content emphasis varies greatly.
(18) Emphasizes more technical aspects of science (facts, mechanical processes, etc).
(19) Main concepts "fall apart" when spread across grade spans.
(19) Document lists vocabulary but offers no definitions.
(20) Lots of physical science with less on living systems.
(20) Sometimes "sets up" students to not do well on assessment (discouraging).

PREVIEW OF LIKELY AREAS FOR RECOMMENDED CHANGES

Based on the input from the Washington Science Advisory Panel and early analysis by the DHA project team, recommendations for improvement of the Washington Science Standards are likely to be made in the following areas:

- **Connections between the standards, curriculum, and assessment.** The review will seek to provide recommendations to enhance existing connections and to build new ones.

- **Content of the standards in terms of grade-level appropriateness and emphasis.** For example, reviewers will consider the appropriateness of using Bloom's Taxonomy verbs in the statements of the standards and the use of scientific vocabulary.

- **Amount of content and balance between standards that address understanding of scientific concepts, scientific skills related to inquiry, and the application of scientific concepts.** The science panel strongly endorsed the inclusion of and emphasis on inquiry in the standards. However, members indicated that the volume of information sometimes makes it challenging for educators to address EALRs #2 and #3. With this in mind, the expert review team will be attentive to the relative amount of content included in each of the EALRs.

- **Structure and usability of the document.** The document will be reviewed with attention to how the structure of the standards may be made more user-friendly for a variety of audiences, such as teachers, curriculum-developers, and assessment coordinators.

- **Strategies for implementation of the standards.** The project team will provide recommendations on the use of standards as the basis for changing policies, programs, and practices.